NAVAL POSTGRADUATE SCHOOL
MONTEREY, CALIFORNIA 93940

IN REPLY REFER TO:

DEPARTMENT OF
MECHANICAL ENGINEERING
CODE 69SL

30 October 1978 20

Dr. L. S. Tong
Nuclear Regulatory Commission
Washington, D. C.

Dear Dr. Tong:

The purpose of this letter is to inquire your thoughts and to seek your assistance regarding an informal proposal.

I became increasingly aware that a sound and cost-effective engineering methodology for dealing with complex problems encountered in the analysis of containment response to accidents requires a critical assessment of the existing knowledge on time-dependent forces on submerged structures. Information on this type of flows is buried in the journals, reports, and books dealing with aeronautical engineering, mechanical engineering, civil engineering, nuclear engineering, etc. An engineer or scientist working on containment problems cannot be expected to be aware with all the papers pertaining to his special question. The diffused nature of the information leads to costly search, repetition, confusion, and over or under design. I feel that it would be very beneficial to the Nuclear Regulatory Commission and its nationally important programs to develop a source, based on past and current research, which will objectively and critically combine the fluid mechanical information pertaining to multicomponent containment systems analysis and will point out the new research areas.

For the past twentyfive years I have worked on time-dependent flows and made some contributions through both theoretical and experimental work. I feel that I can prepare a very comprehensive report on the said subject, should it be found desirable by you and NRC.

Attached is a topical outline for the proposed project. It can be expanded to cover additional topics to suit the needs of NRC.

I would appreciate it very much if you would be kind enough to let me know your thoughts regarding my proposal.

With best wishes, I remain

Sincerely yours,

Dr. T. Sarpkaya
Distinguished Professor of
Mechanical Engineering,
Naval Postgraduate School
Monterey, Calif. 93940

Ph: (408) 646-2588
Autovon: 878-2588

CC: Dr. S. Levine

Encl: an outline

TS:vc

D-106

Prof. T. Sarpkaya

AN OUTLINE

TIME-DEPENDENT FLOWS ABOUT SUBMERGED STRUCTURES

I. Objectives and relevance to reactor safety

II. On separation and time dependence

1. Introduction
2. Consequences of separation
3. Forces on bluff bodies
4. Force decomposition: drag, lift, and inertia
5. Strouhal number and vortex shedding

III. Special Time-Dependent Flows

1. Introduction
2. Impulsively started flows
   a. kinematics and dynamics
   b. small-time and late-time analysis, experiments
   c. force coefficients
3. Uniformly accelerating flows
   a. kinematics and dynamics
   b. analysis and experiments
   c. force coefficients
4. Harmonically oscillating flows
   a. small amplitude oscillations (inertia-dominated regime)
   b. medium amplitude oscillations (drag/inertia dominated regime)
   c. large amplitude oscillations (drag dominated regime)
5. Flows subjected to arbitrary time dependence
   a. force analysis
   b. deterministic and stochastic methods
6. Steady and time-dependent jets
   a. jet boundary evolution
   b. velocity and acceleration fields
   c. forces exerted by jets on bluff bodies
   d. impinging jets, evolution of impingement
   e. multiple jets and mixing
   f. vortex rings and jet development

IV. Numerical Methods of Analysis

1. Finite-difference techniques
2. Finite-element methods
3. Marker and Cell techniques
4. Discrete vortex models
5. Application of the methods to flow about bluff bodies and to jet evolution with time

V. Multiple Bluff Bodies and Proximity Effects

1. Definition of the problem
2. Forces on multiple cylinders
   a. forces in the inertia-dominated regime (no separation)
   b. forces in the drag/inertia dominated regime
   c. forces in the drag dominated regime (lift and drag)
3. Methods of analysis, potential flow methods
4. Wall proximity effects on forces on bodies and on jet evolution
5. Forces on multiple oblique cylinders
   a. interference effects and shielding
   b. lift and drag forces, lift amplification

Continued

VI. Hydroelastic Response of Bluff Bodies

1. In-line and transverse oscillations in steady flow
2. Hydroelastic oscillations in time-dependent flows
3. Hydroelastic oscillations of multiple cylinders
4. Scale effects in hydroelastic response
5. Methods of analysis

VII. Modeling Laws and Special Considerations

1. Fundamentals of modeling in containment analysis
2. Sensitivity analysis
3. Error bounds
4. Comparison of numerical and experimental models with prototype

VIII. Special Topics Directly Related to Containment Analysis

1. LOCA and SRV submerged structure loads
    a. their relation to time-dependent flows
    b. upper and lower bounds of forces (lift, drag, frequency)
2. LOCA and SRV jet loads
    a. their relation to jet analysis
    b. upper and lower bounds of jet forces
    c. wall and body-proximity effects
    d. hydroelastic oscillations in LOCA and SRV
3. Bubble-Induced Loads
    a. in ramshead and quenchers
    b. bubble-bubble and bubble-body proximity
    c. bubble shape non-uniformity

IX. New Research Areas

1. Experimental and theoretical research areas in
    a. forces on bluff bodies
    b. jet evolution and jet loads
    c. hydroelastic oscillations
    d. sensitivity analysis and functional dependence

X. Epilogue on the state of the art